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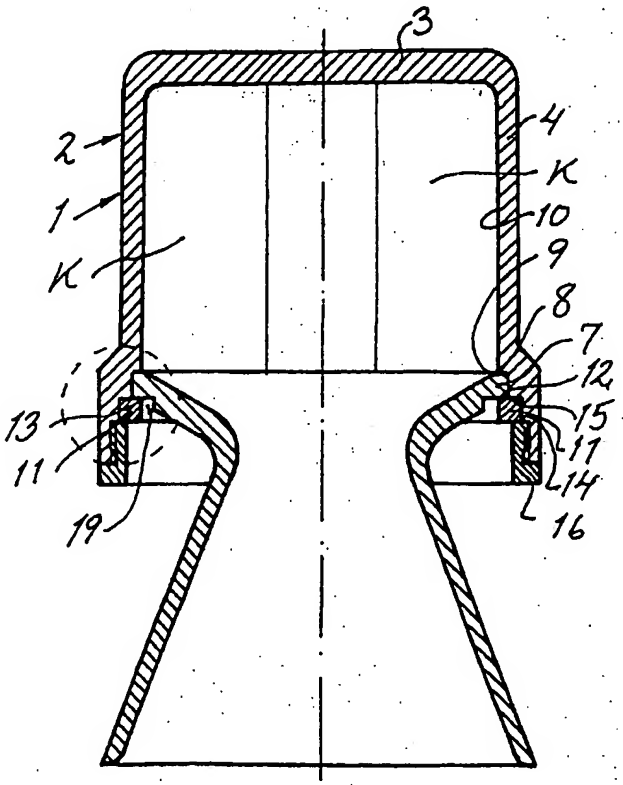
(54) Title: METHOD AND ARRANGEMENT FOR PREVENTING ENCASED EXPLOSIVES BEING CAUSED TO EXPLODE BY AN EXTERNAL FIRE



(57) Abstract: The present invention relates to a method and an arrangement for, in connection with a possible external fire in an ammunition bunker, preventing products container therein comprising encased explosives, such as for example rocket engines, exploding. The basic principle underlying the invention is that the casing (2, 6) surrounding the explosive is to consist of a number of parts which are held together by mounting components (11) made from shape memory alloy, the properties of which are selected in such a manner that these mounting components no longer hold the various parts of the casing together if the surrounding temperature rises to such a great extend that the ignition temperature of the explosive begins to approach.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Method and arrangement for preventing encased explosives being caused to explode by an external fire

The present invention relates to a method and an arrangement for, in connection with an external fire in an ammunition bunker, preventing ammunition components stored therein, and then perhaps chiefly rocket engines, from exploding. The invention is based on, in the quantity of explosive enclosed in each ammunition component, before the explosive has reached its ignition temperature as a result of external heating but during the gradual decomposition of the explosive during heating, allowing combustion gases formed in this connection access to a free gas outlet of sufficient cross-sectional area in order to prevent the heating resulting in an explosion. The object of the invention is therefore to limit the damage caused by a fire in the event of external heating of the products concerned here.

The state of the art includes a number of various different proposals with regard to how rocket engines could be prevented from exploding in the event of external fire in, for example, the ammunition bunker where they are stored awaiting use. Several of these earlier proposals are based on making the outer casing of the rocket engines of at least partly temperature-sensitive or fire-sensitive material which, in the event of external fire, will be capable of, from the outside, being weakened sufficiently or being burnt through completely before the propellent powder of the rocket engine has reached its critical ignition temperature. In these older methods as well, the intention is therefore to limit the damage caused by a fire by making sufficient gas outlets available when the gas pressure inside the engine rises to such a great extent that an explosion would otherwise result.

Variants on this subject are described in US-A1-4,084,512, US-A1-4,442,666 and US-A1-4,458,482.

SE-A2-508,650 also describes a method and an arrangement for, with the same intention, preventing an external fire in an ammunition bunker containing fixed artillery ammunition with a charge consisting of what is known as LOVA powder giving rise to an explosion. The burning rate of the LOVA powder is heavily pressure-dependent and, according to this earlier proposal, the cases of the fixed ammunition were therefore provided with weakenings which, when fired in the weapon concerned, cope with the barrel pressure as long as they are supported by the chamber of the weapon but, if they do not have the support of the chamber, break and split open when the internal gas pressure rises above a predetermined value.

The invention concerned here therefore relates to an attempt to solve a previously known problem in a radical new manner. Instead of making use of fire-sensitive outer material in the cases or equivalent enclosing the explosive or of providing the same cases with weakenings made beforehand, we are now proposing making the cases enclosing the explosive in a number of separate parts and assembling these case parts purely mechanically with inserts or mounting components which are made from what are known as shape memory alloys. These inserts or mounting components are also to have such properties that, at a preselected temperature which lies well below the temperature when an explosion is imminent, they eliminate the interconnection between the case parts concerned so that the gas formation which precedes an explosion has a free outlet. In order for this basic principle to be capable of functioning, it is necessary that it is not possible for the mounting components made of shape memory alloy to be heated to their own critical temperature during the

burning time of the rocket engine as they will then initiate the safety function built into the invention.

The shape memory alloys, of which there quite a number and which all actually consist of various alloys which may be based on nickel-titanium or hafnium-palladium or a number of other metals, can be imparted very precise temperature-defined deformations. These deformations, which are built into the metal during manufacture of the component, may involve contraction or expansion of 4-8% but also direct built-in pure deformations, and it is possible to define relatively accurately beforehand at which temperature these are to take place. The built-in deformation temperature of the shape memory alloy and whether the deformation involves expansion or contraction is defined by controlling the alloying materials and the alloying contents and in the manufacturing process itself, and the manufacturing process also makes it possible to define even the actual shape the component concerned will have after initiation of the deformation of the shape memory alloy. The principle is that, at temperatures above the critical temperature, the shape memory alloy recovers the shape and dimensions it once had before it was imparted a different shape by various processing operations. If, on the other hand, its temperature should fall below the critical temperature, its shape and dimensions then revert to those the component had before heating. It may sometimes also be advantageous for it to be possible to return to the original shape by virtue of a temperature reduction, and this is possible because, when the change takes place, it therefore lasts only as long as the temperature lies above the critical transformation temperature. In the context of the present invention, however, it is primarily the first transformation step which is relevant. The change which takes place at the critical temperature involves a return to an original state which the shape memory alloy component had before it

was transformed by virtue of various procedures into the state which subsequently applies as long as its temperature does not exceed the critical temperature. In principle, the shape memory alloy component has an unlimited storage time provided it does not reach its critical temperature.

The method of producing the connection component made of shape memory alloy which is characteristic of the invention does not form part of the invention and will therefore not be discussed in greater detail below either. On the other hand, it would not constitute any great problem for a person with the requisite knowledge within the shape memory alloy field to produce the connection components necessary for implementation of our invention.

The invention has been defined in greater detail in the patent claims below and will now be described somewhat further in connection with the accompanying figures.

Fig. 1 shows a longitudinal section through a rocket launch engine with a short burning time, while
Fig. 2 shows a detail from Fig. 1 on larger scale.

The rocket engine 1 according to the figure consists of a powder chamber 2 which is in the form of a cylindrical pot with a plane bottom 3 and continuous side walls 4 and contains propellent powder K. In the initially open other end 5 of the powder chamber 2, a rocket outlet nozzle 6 is inserted into a stop position intended for it, in which its outer flange edge 7 bears with its inwardly facing broad side 8 against a stop edge 9 adapted thereto in the inner wall 10 of the powder chamber. The rocket outlet nozzle 6 is then held in place by a ring 11 made of shape memory alloy which is arranged outside the flange edge 7 and bears with an inner flank 12 against the outer broad side 13 of the flange edge 7. The shape memory alloy ring 11 is in

turn fixed in a locking groove 14 in the inner wall 10 of the powder chamber 2. This locking groove 14 is then in turn formed between an inner outwardly facing stop edge 15 and a stop ring 16 screwed into the outwardly facing opening of the powder chamber.

It is also the case that the maximum diameter of the flange edge 7 is not greater than can pass through the stop ring 16, and that there is a space 19 available between the inner edge of the locking ring 11 and the rocket outlet nozzle 6 which allows the inner diameter of the locking ring 11 to contract sufficiently in order for it to fall out of the locking groove 14 and to be capable of, together with the flange edge 7 of the rocket outlet nozzle 6, passing the locking ring 16. According to the invention, this contraction function has therefore been built into the ring 11 by virtue of the latter having been manufactured of a shape memory alloy adapted thereto which accordingly activates the contraction function at a predetermined temperature which lies well below the ignition temperature of the propellent powder K. If the ring 11 is heated to the critical transformation temperature of the shape memory alloy, this contraction of the ring consequently takes place, the rocket engine nozzle 6 then no longer being firmly connected to the powder chamber 2, as a result of which its entire cross-sectional area becomes available as a gas outlet, and what would otherwise have been an explosion is replaced by a powder fire, which can be serious enough but never as devastating as an explosion.

Patent Claims

1. Method for, in connection with a possible external fire in an ammunition bunker, preventing products (1) contained therein comprising encased explosives (K), such as for example rocket engines, from exploding, characterized in that the respective casings (2, 6) of products contained therein are already divided into a number of separate parts (2, 6) during manufacture, which are assembled into a unit which serves the main purpose, held together by mounting components (11) made from shape memory alloy, the type of shape memory alloy and the critical temperature at which its memory function is initiated and also the design of the mounting components (11) being selected in such a manner that the casing, before the explosive (K) has reached its own ignition temperature as a result of external heating, is transformed to consisting of parts (2, 6) which are no longer firmly interconnected by virtue of the mounting components (11) having recovered their original shape at the critical temperature of the shape memory alloy and as such no longer holding the various parts of the casing together.

2. Method according to Claim 1, characterized in that the mounting components (11) made of shape memory alloy are given such a positioning in the finished casing (2, 6) that it is never possible for the shape memory alloy to reach its critical temperature during normal use of the encased explosive charge (K).

3. Arrangement for, in accordance with the method according to Claim 1 or 2 and in connection with external fire in an ammunition bunker, preventing products (1) contained therein comprising encased explosives (K), such as rocket engines, exploding as a consequence of having reached their ignition temperature as a result of external heating, characterized in that the casing (2, 6) of each product

consists of a number of parts which are held together by mounting components (11) made of what is known as shape memory alloy, the transformation temperature of which is selected in such a manner that it is considerably lower than the ignition temperature of the explosive (K), and the shape of the mounting components (11) after having reached the transformation temperature being such that they no longer hold the various parts of the casing together.

4. Arrangement according to Claim 3, characterized in that the mounting components made of shape memory alloy are positioned in such a manner in the casing that, during the intended use of the product, it is never possible for them to reach the critical transformation temperature of the shape memory alloy, at which its memory function is activated.

5. Arrangement according to either Claim 3 or 4, characterized in that the casing of the explosive (K) comprises a container (2) which is closed to the sides and at least one end wall (6) of which consists of a separate unit which is guided down into the container and there bears, along its inwardly facing outer edge (9), against an inner stop edge (8) which is arranged in the container wall and limits the possibility of movement of the end wall (6) into the container (2), and in that said end wall (6) is held in place by a locking ring (11) made of shape memory alloy arranged outside it, said locking ring (11), in the original position, on the one hand bearing against the outer side (13) of the end wall along the outer edge thereof and in this way holding it pressed against the inner stop edge (8) of the container, and on the other hand entering a locking groove (14) which is arranged in the container wall and, as long as the locking ring is in place, fixes its position in the container and thus also the position of the end wall in the container, and the internal diameter dimension of the locking groove

being selected in such a manner that the end wall can pass it and out of the container as soon as the locking ring is no longer in place in the groove, and the locking ring being made of a shape memory alloy which, at a selected critical temperature which is lower than the ignition temperature of the explosive, contracts to an original outer dimension which means that it comes out of its locking groove and can pass out of the container.

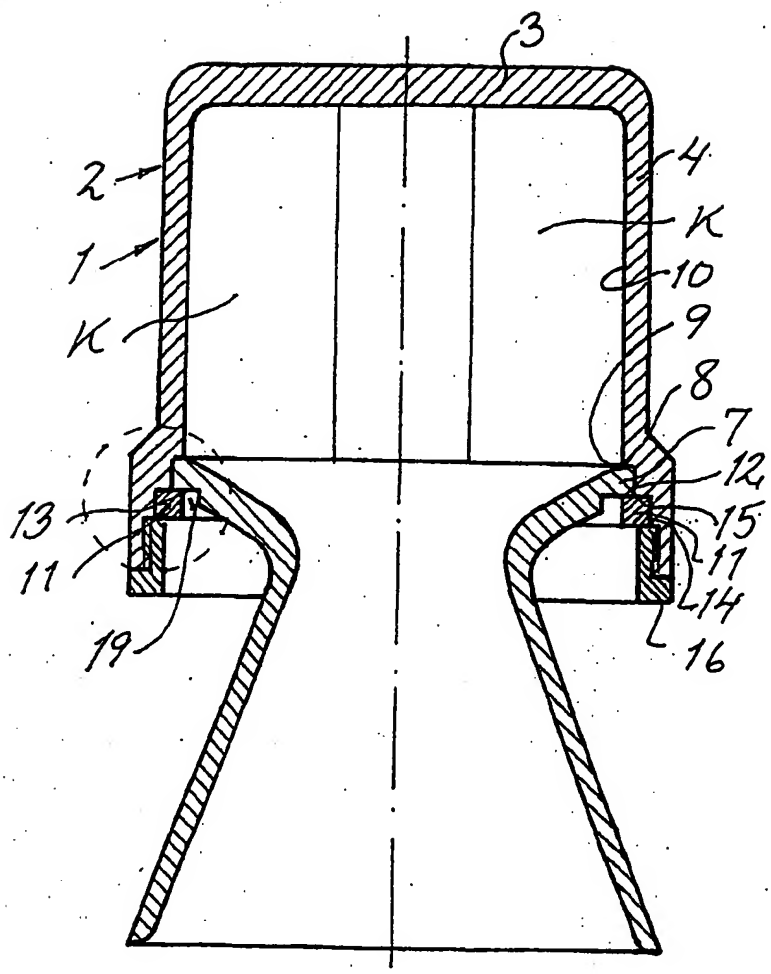

Fig. 1

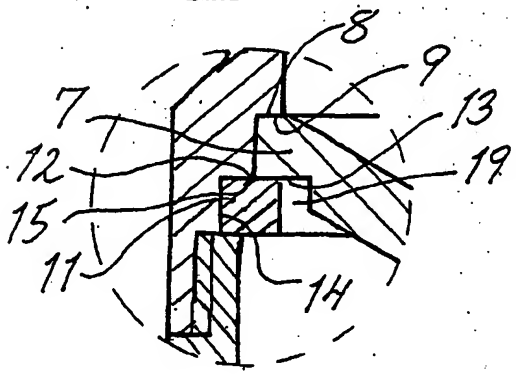

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 01/01370

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F42B 39/20
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F42B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2686410 A1 (ETAT FRANCAIS), 23 July 1993 (23.07.93), figures 1-3, abstract	1-4
A	--	5
A	FR 2742221 A1 (SOCIETE DES ATELIERS MECANIQUES DE PONT SUR SAMBRE SAMP), 13 June 1997 (13.06.97)	1-5
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A	EP 0540418 A1 (ETAT FRANCAIS), 5 May 1993 (05.05.93)	1-5
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A	US 5445077 A (DUPUY ET AL), 29 August 1995 (29.08.95)	1-5
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☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 Sept 2001	28 -09- 2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Mariana Eddin/EK Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/09/01

International application No.
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